1-1-2016

9.0.C.1 Hands-on Evaporative Cooling and Molecular Adhesion

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Mini-experiments: Extensions of activities regarding phase change

You will be organized into new groups of 4 or 5.

Manager:	person whose last initial is closest to H in alphabet, then…
Recorder:	person at table who has been recorder the least, then …
Spokesperson:	of remaining people, person with longest first name
Reflector:	the last person, or if there are two people left, do one round of rock/paper/scissors

You can go in any order.

You will need eye protection.

Records can go onto the Recorder Report.

Pay particular attention to the underlined questions in the procedures. Respond to all of those. You can add more information if you feel it is appropriate. Remember this is a record for you (and something that will be posted on BB for entire class to review).

The following materials are on the side bench. Obtain and return as needed.

- Tray of droppers containing water, olive oil, and methanol
- Wax paper
- Thermochromic paper
- Wood toothpicks
- Balloons
- masking tape
- paper towels
- plastic dishes
- water ice
- computer spray

Christopher F. Bauer, Principal Investigator.
This material is based upon work supported by the National Science Foundation under Grant No. 1245730.
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Mini-experiments: Extensions of activities regarding phase change

A) Watching water and methanol evaporate

Materials: thermochromic paper, tray of droppers

Procedure: do this in pairs, but share observations

1) Take a small piece of ice and place it on the thermochromic paper. Take note of what you see. This suggests that the thermochromic paper can be used to detect something. What will it be able to detect?
2) Wipe the thermochromic paper dry with a paper towel, and let it return to room temperature. Carefully, place one drop of water onto the paper. Watch. (Patience) You can repeat this to make sure it's not a fluke. Describe what is happening. Then attempt to explain what you see.
3) While you are mulling over your explanation, on a different part of the thermochromic paper, place a drop of methanol (toxic if ingested in large quantities). Again watch, describe what you see (same as water?), then attempt to explain what you see. In particular, keep watching when the methanol droplet is gone.

In concise sentences, describe what is happening here, and provide an explanation that you think accounts for what you see.

B) On the side bench is a can of computer cleaner spray. It contains a non-toxic, non-reactive gas called difluoroethane. DO NOT SHAKE THE CAN. DO NOT PRESS SPRAY BUTTON UNTIL INSTRUCTED.

1) Have someone bring the can to your table.
2) Pass the can around to determine two things: how warm or cold does it feel, and does it seem to contain a gas or a liquid.
3) Whoever is holding the can, spray it (away from anyone) for about 5 seconds. Note two things: what comes out of the can, and how does the can start to feel
4) Next person, spray for 1 second, and feel the can. Keep going til everyone has a chance. Describe how the can felt after spraying – see if everyone agrees.
4) Briefly, spray the thermochromic paper. Observe. Describe what you see.
5) Return the can to the side bench.
6) Summarize your observations. Then, attempt to explain what you observe.

Experiments A and B are related. How so?

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Mini-experiments: Extensions of activities regarding phase change

C) Materials: wax paper (2 pieces), paper towels, tray of droppers

Procedure: do this in pairs, but share observations

1) Put down paper towels on the table. Lay a square of wax paper over that. Tape the corners to flatten it as much as you can.
2) Put on small droplet of water onto the wax paper.
3) Take a tookpick. Wet the wider end with water. Stick that end into the droplet on the wax paper. Move the toothpick and drag the droplet across the surface. Give everyone in group a chance to play.
   How well does the droplet go with the toothpick?
   In the simplest terms possible, what is the droplet doing?
4) Put two small droplets of water on the paper. Using the toothpick, move one really close to the other droplet. Closer. Closer. Until something happens. Give everyone a chance to do this.
   Describe what happens using some rich adjectives.
   Describe what must be happening at the molecular level to cause these observations.
5) Wipe the wax paper surface dry. Now try the same procedure using droplets of olive oil
   Describe what happens. Compare and contrast the oil's behavior vs the water.
   Then relate what you see to the molecules.

D) Materials: large beaker, paper towels, tray of droppers, balloon

Procedure: do this in pairs but share observations

1) Inflate the balloon to about softball size and tie off.
2) Hold the water dropper over the beaker so that you can slowly squeeze out some drops one at a time. Note how they fall.
3) Rub the balloon on your hair. What does this do to the balloon?
4) Hold the dropper to one side of the beaker, and the balloon 10 inches away horizontally.
5) Slowly move the balloon toward the dropper, releasing water drops slowly as you do so.
6) What do you observe about the falling droplets? When that starts to happen, adjust the position of the balloon very carefully.
7) Propose a tentative explanation for what you see.
8) Repeat this procedure using olive oil droplets.
9) Compare how the oil behaves with how the water behaves, and reconsider your explanation for the behavior.

Experiments C and D are related. How so?

Expts ABCD should reveal something about the properties of molecules that helps explain your model for how chemical substances respond to heat. Discuss this and develop a several sentence explanation that tries to tie these things together (this set of experiments, with the heating/cooling curve experiments).

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RECORDER REPORT, Chem 444A "Fire & Ice"

Group Member Name	Role	Date: 2/19/15
Charles	Recorder	
Marisa	Spokesperson	
Taylor	Reflector	
Emily	Manager	

A) 1) The ice on the paper looks like an oil spill in water. The paper detects different levels of ~~heat~~ cold, depending on the color it shows. - detects thermal changes

2) The drops of water are turning a purple/blue color. Then after a while, it turns green - it seems like a mood ring. It changes at a much slow rate than the ice, probably because of the warmer ~~temperature~~ of the water.

2) The color seems to go from purple → green → yellow

3) The methanol is going through the color changes very rapidly - is the experiment trying to show how quickly a substance can take in or release heat?

3) The methanol is shrinking, or evaporating, and the color changes back to purple

In conclusion, the color changes show the changes in ~~energy~~. the speed of the molecules. (see #6 below)

B) 3) It seems as if a transparent stream of air is coming out, but the can begins to feel colder.

4) The cold seems to rise to the top of the can

5) The sprayed area creates a ring of orange, green, and purple (from inside to out)

6) As things are changing state, they draw heat from their surrounding environment, and causes the can to feel colder.

A+B Today we learned that the paper uses color to show the loss of heat, while the can uses the physical sensation of cold to depict this loss.

C) 3: The droplet is similar to a dog on a leash. It follows the toothpick, but trails it ever so slightly.

4: The wet bubble, being dragged ever so gently, across the smooth wax paper, quickly ~~collides~~ merges with the other bubble. At the molecular level, the molecules are bonding together and are able to be dragged around without breaking.

5) The oil didn't bead up as much because it is a lipid, like the wax paper. As a result, the oil couldn't be dragged, but was only spread out. The oil molecules aren't as attracted to eachother as much as the water molecules were, but are instead equally attracted to the wax paper.

D) 6) The droplets are attracted to the balloon and begin to be pulled in its direction.

7) When the balloon is rubbed onto hair, the balloon is giving electrons to the hair. The balloon becomes positively charged, and the negative parts of the water are then attracted to the balloon.

9) The oil droplets were not attracted to the balloon, because the oil is not polar, like the water is.

C+D) Both of these experiments study polarity and how different substances are attracted to others. The water reacted negatively or positive in the situations, while the oil had no reaction.

1+B+C+D) All of these experiments look at how bonds are broken between molecules, and how they are attracted to eachother. We know the more bonded things are, the harder it is for them to change state. That means that weaker bonds are easier to break, as shown by dragging the oil. Finally, bonds are broken by the presence of heat.

RECORDER REPORT, Chem 444A "Fire & Ice"

Group Member Name	Role	Date: 2/19/15
Samantha	Manager	
Miriam	Recorder	
Kyle	Reflector	
Becky	Spokesperson	

1) 1) Detects changes in temperature

2) starting to turn blue underneath droplet. Blue ring begins to form around. Starts to turn greenish, then yellowish. Displays cohesive properties. Specific heat of water is high so water absorbs heat slowly.

3) Methanol makes paper change color more quickly. Left with a rainbow ring of colors around where methanol was placed in seconds. Specific heat of Methanol is lower than water thus it absorbs heat quicker. Methanol evaporates faster than water and rings close in. Methanol spreads out more which increases surface area which could speed up absorption.

2)

- Droplet moves very well with the toothpick.
- Phagocytotic. Big droplet engulfed and swallowed smaller droplet.
- Hydrogen bonds form and molecules are strongly attracted to each other
- Oil is not as cohesive. It spreads out. Oil molecules must not be as strongly attracted as water molecules. Drops combine but neither is engulfed they simply touch and become one.

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D) - Drops fall straight but then begin to fall in the direction of the static balloon. Angle of drop-fall is more dramatic as the balloon moves closer.

- Static electricity of balloon attracts the charged molecules in the water droplets.
- Oil drops straight down. So oil molecules most likely has weak to no charge.
  Water is good conductor of electricity, oil is not.

C&D → Water is cohesive because it is polar molecules, oil does not have the same strong polar charges as water.

B) - Can feels cooler when sprayed. Gas comes out of the can.
- Can felt cooler after spraying, especially the top near the nozzle.
- Gas only affected paper when it was very close. Colors appeared quickly, but also went away rapidly.
- Gas is cold, thus draws heat from the paper. Gas could be removing heat from liquid to enter different state, thus causing the can to feel cooler. Temperature and pressure may be positively related, thus if pressure is released temperature may decrease.

A&B → Both liquids and gas were able to absorb heat from the paper.

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spray can

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Group Member Name	Role	Date: 2/19/15
Amanda Graves	Manager	
Emma Adamson	Recorder	
Kaleigh Zurowski	Reflector	
Timothy Closson	Spokesperson	

A. 1. It will be able to detect heat or lack of heat.

2. The ~~water~~ paper is changing color (under the water) just like it did for the ice. We think this might be because the paper is removing the heat.

3. The methanol changed colors just like the water but a lot more rapidly and then it evaporated. Therefore this refutes our previous explanation. Maybe methanol's boiling point is very close to room temperature and the thermochromic is detecting enough heat for it to hit that point, or maybe not. We know this has something to do with changing temperature and phases but we aren't sure ~~how~~ why methanol is changing phases.

B. 3. ~~I~~ Initially we see remenants of a liquid or vapor; but then it is just gas. Then the can felt warmer.

4. We all agreeded that the can felt slightly ~~warmer~~ colder. Can my have been empty?

5. When you spray the can on the paper it has the same affect as the ice and causes the paper to change colors.

6. The computer spray causes the paper to be colder and then afterwards the paper goes back to room temperature which is why it does back to ~~black~~ blue.

A and B are related because both experiments had to do with temperature and energy changes, however exactly ~~what~~ what is happening with the liquids and gas is still [illegible]

C. 3. Very well it ~~move~~ stays intact as it moves around the wax papes

4. The water droplets almost jump together.

In the molecular level the molecules bonded together and took a somewhat definitive shape. Ie. they now all move together in one blob or ~~droop~~ droplet

5. The oil doesn't join into one droplet. It doesn't hold a definitive shape and sort of spreads out. The molecules therefore must not bond together. Maybe hydrogen bonds are stronger?

D. 6. When the balloon gets close enough the water droplets are attracted toward the balloon.

7. ~~Karen~~ Before you rub the balloon on your hair the water and balloon have the same charge. Then once you rub it on your hair it causes it to have the oposit charge which causes the water molecule ~~so they don't react~~ and balloon to attract. This is all possible because the water is polar

9. The static balloon has no affect on the oil. Just how the oil didn't stick together on the wax paper it didn't stick to the balloon. This substance is nonpolar therefore ~~the~~ it didn't attract.

The water stuck together on the paper and the oil didn't, and this was exactly what happened with the balloon. The balloon just allows you to see this better because the oil has no reactions to it.

Experiments C and D showed how water has very strong bonds compared to the other liquids. This could easily be seen in the way that the water droplet stayed together on the paper where the other liquids spread apart. Then this was enforced with experiments A and B because it took the water droplet longer to evaporate on the paper. This also reinforces the concept that different liquids have different evaporation points.

RECORDER REPORT, Chem 444A "Fire & Ice"

Group Member Name	Role
Nicholas	spokesperson
Amanda	manager
Eliza	rerorder

Date: 02/19/15

[redacted]

(A) 1) We observed a dark circle beneath the ice with changing colors spreading away from the ice (a spectrum from bright to cool colors as it moves away)

- Able to detect cold substances and show the degrees of coldness through colors (cold = bright color, cool = darker colors)

2) The area beneath the droplet turned blue/purple. The outer ring is a darker color than the rest of the droplet whereas the middle became brighter in color.

- both water and paper are exactly room temp.

3) similar effect that we saw with ice — a spectrum of colors — but on a smaller scale (rings of colors are thinner and more difficult to decipher.

- methanol evaporates very quickly

Notes: where phase change occurs, the color indicates which transition in phases. In the middle, the molecules are more concentrated with a stronger bond. toward the edge, the molecules are further apart and evaporate more easily, as we saw with methanol.

(B) 1) A clear gas is released and the can gets colder the longer you spray. The group agrees

2) As we sprayed, a colored spot appeared, with the same spectrum of colors as the other substances. The longer we sprayed it, the brighter the colors got

Relating A & B:

Temperature of can and paper both decrease as energy is transferred to the substance in order to change phases. The can feels colder whereas the paper changes color, therefore the paper is becoming colder.

(C) 1) Not exactly stuck to tooth pick, but drawn [illegible] by the water already on the end.

2) Water molecules on tooth pick are bonding with water on wax paper.

3) Two droplets immediately (upon contact) merge.
- Hydrogens rapidly connect to the oxygens and form a bigger structure

4) Oil stays still and forms a streak. The molecules in the oil have weaker bonds and are easily pulled apart which alters the shape whereas the bond in the water is strong and maintains its shape

(D) 1) The droplets are attracted and pulled toward the balloon. The droplets make contact with the balloon.

2) The water and the balloon have opposite charges because they are attracted to each other.

3) The oil is not attracted to the balloon's charge.

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Group Member Name	Role
Jon	—
Heather	Speaker
Emily	Manager
Jake	Reflector
Sean	Recorder

Date: 2-19-15

[redacted]

Ats

Thoughts

A) $_{sol}$ 1. It starts turning color, with a Rainbow Ring, Detects cold temperatures?

$H_2O_{(g)}$ 2. very slowly It is turning violet, to green (under the droplet) evaporation?

$CO_{(l)}$ 3. began to change quick, similar to the Ice, the Methanol is evaporating

* only Responds to cold, The change in Phase causes energy to transfer from Paper (cooling it) Like sweat

B)

- The can is cold, and feels, and sounds like a liquid when shook.
- gets colder as you shake it.

Sprayed 5sec...

the can began to feel cold, "air" comes out of the can when Sprayed on the thermochromic Paper: it detected the cold temperature

* went from Liquid to a gas,

* like the evaporation of the Methanol, the Phase change of the ~~can~~ diflouromethane cause energy to leave the Paper.

C.

- the water droplet follows the toothpick around (connects to, and sticking to the toothpick)

- the two droplets merged together, as the droplets become bigger and bigger they become harder to move around

* the molecules are bonding together to some degree they are forming Hydrogen bonds, or in otherwords they are more attracted to eachother Rather then the wax paper, gravity eventually took over and was stronger then the H bonds.

- the oil does not follow the tooth pick, Nor stay in a droplet it just spreads

* there are apparently no intermolecular forces at work

D.

the charged balloon attracts the water, so as to not drop straight down.

the balloon does not effect the oil

* the charged balloon, and the Polar water are attracted whereas oil Is not Polar, and has no attraction.

A both C+D explore Properties of water and oil, and their Polarity